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BRIEF REPORT

Modulating the Er:YAG Laser

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Background and Objectives: **In the past 2 years, there has been some controversy about the optimal laser system, or combination of systems, for cutaneous resurfacing. Initially, it seemed that the Er:YAG laser would have significant advantages over the CO_2 laser. In practice, some of those who jumped early onto the Er:YAG bandwagon have been unimpressed with the degree of skin tightening that can be achieved with this system. Also, the excessive bleeding induced by the Er:YAG lasers prevented deeper vaporization. During the past 18 months, three new "modulated" Er:YAG lasers have been produced that are said to be able to achieve CO_2 laser-like effects, while maintaining the Er:YAG laser advantages. The purpose of this article is to examine these new systems and to discuss their potential benefits, if any, over the "conventional" Er:YAG lasers, and the CO_2 lasers.**

Study Design/Materials and Methods: **The author has collected data from his own experience and that of his colleagues in the department of dermatology at University of California at San Francisco. The author has used all three types of modulated Er:YAG laser on patients presenting for cosmetic laser resurfacing and the treatment of many benign conditions over an 18-month period.**

Results: **All three modulated forms of Er:YAG lasers have been demonstrated to provide better coagulation than the conventional Er:YAG lasers. The Derma-K and the Contour Er:YAG lasers were able to induce tissue contraction/desiccation similar to the CO_2 laser. The author and his colleagues have induced only two cases of permanent hypopigmentation in over 50 cases during the past 18 months while using the Er:YAG laser, significantly less than might be expected with the CO_2 lasers.**

Conclusions: **If a laser surgeon is happy with the results obtained with a high-energy, short-pulse CO_2 laser, then there seems little reason to consider changing to an Er:YAG laser. The modulated Er:YAG lasers have definite advantages over the conventional Er:YAG lasers. They exhibit better control of hemostasis and can ablate tissue to a greater depth than the conventional Er:YAG lasers. The Er:YAG lasers might induce less permanent hypopigmentation than the CO_2 lasers. Lasers Surg. Med. 26:223–226, 2000** **© 2000 Wiley-Liss, Inc.**

Key words: CO_2 laser; collagen; rejuvenation; resurfacing; thermal injury

INTRODUCTION

In recent years, there has been considerable interest in the development and use of the Er:YAG (Erbium:YtriumAluminiumGarnet) laser for cutaneous resurfacing, either by itself or in combination with the high-energy, short-pulse CO_2 laser [1,2]. Some who thought that the Er:YAG laser might replace their CO_2 laser have been disappointed [3]. This brief review examines

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the reasons behind the latter sentiment and explores new developments that are likely to remedy the problem.

The Er:YAG laser has been considered useful in three arenas. First, the Er:YAG laser has been used effectively for superficial laser abrasion, removing the epidermis and superficial dermis, although deeper vaporization has been hampered by ineffective hemostasis. Second, the Er:YAG laser has been touted as a superior laser for resurfacing the neck and hands. Third, the Er:YAG has been used for removal of thermally altered tissue after conventional CO_2 laser abrasion, a feature that is said by some to hasten healing and reduce erythema. There is some evidence that use of the Er:YAG laser is associated with much reduced permanent hypopigmentation in comparison to CO_2 laser abrasion (Mitchel Goldman, personal communication). For this reason alone, many physicians are considering incorporating or switching to an Er:YAG system.

The coefficient of absorption of the Er:YAG by water is approximately 10 times that for the CO_2 laser. Consequently, the Er:YAG laser will ablate tissue efficiently at a relatively low fluence of about 0.5 to 1.5 J/cm^2. This efficient ablation is associated with minimal residual thermal damage. The lack of thermal damage has been touted as one of this laser's best features. But in practice, it is also one of its main detractions. Indeed, one can say that the conventional pure ablative Er:YAG lasers will not realize their promised potential unless a certain degree of hemostasis can be achieved.

Modulated Systems

Three Er:YAG lasers offer the capability of combining ablation and coagulation. The Derma-K (ESC, MA) is a *hybrid* system that combines a conventional Er:YAG laser with a coagulating CO_2 laser of low power. The other two systems offer a modulated feature. Specifically, the *dual mode* Contour (Sciton, Palo Alto, CA) comprises two Er:YAG laser heads providing both short-pulse ablative, and long-pulse subablative coagulative components. The third system is the CO3 (Cynosure, MA), a *variable pluse* Er:YAG laser that produces single pulses of variable length, i.e., short pulses being more ablative and longer pulses being more coagulative.

A discussion of these lasers is best provided by someone who has had extensive and equal experience with all three systems. In practice, few of us are without some bias based on personal experience, and we tend to use the system that, in our hands, works best. So let it be said from the outset that the author has had very considerable experience with the Sciton Contour system and that this is his preferred Er:YAG laser. That said, all these systems work nicely, and all have their champions. The purpose of this article is to examine these new systems and to discuss their potential benefits, if any, over the "conventional" Er:YAG lasers and the CO_2 lasers.

Need for Thermal Damage

All the high-energy, short-pulse CO_2 lasers induce epidermal ablation with the first pass, and some degree of dermal ablation with increasing thermal coagulation on the second and subsequent passes. A "plateau of ablation" is reached, at which point further treatment with the CO_2 causes little additional vaporization and is unwise.

The conventional Er:YAG lasers offer a dilemma for the ablation purists. Is ablation alone enough to cause sufficient "tightening" to the skin. If not, what induces tissue shrinkage? Does the desiccation of tissue (responsible for visible tissue shrinkage) persist to any degree? Does this act as a contracted scaffold on which the new matrix is based? Many believe that some degree of thermal spread is necessary for optimal tissue tightening, so as to induce contraction of existing collagen fibers [4]. Laser surgeons who are familiar with high-energy, short-pulse CO_2 laser are used to seeing tissue contract visibly before their eyes. When they switch to the Er:YAG laser, they are generally disappointed to see little evidence of their old friend [5].

How Modulation Makes a Difference

"Tissue contraction" is commonly seen while using the conventional Er:YAG lasers around the eyes. This effect appears to be related to the thin dermal tissue in this region. Desiccation and "tightening" of tissue in other areas is less apparent. Herein lies the potential benefit of the new modulated Er:YAG systems, for they can give a degree of thermal desiccation quite similar to that of the CO_2 laser, given use of appropriate parameters. The modulated Er:YAG lasers can induce controlled thermal desiccation of tissue by a number of methods.

The Derma-K can be programmed to delivery a low-fluence subablative CO_2 pulse immediately after the ablative Er:YAG pulse. The coagulative CO_2 pulse is designed to fill part or all of the time

between the Er:YAG pulses, the so-called duty cycle. Thus, a 50% CO_2 duty cycle pulse would fill half of the "off" time, and a 100% duty cycle CO_2 pulse would fill all of the "off" time. The power of the CO_2 laser also can be varied. In the clinical situation, laser surgeons tend to use at least 50%, and often 100% duty cycle CO_2, since this setting really does give excellent control of hemostasis and good contraction of tissue.

The CO3 Er:YAG laser is designed to produce single pulses of variable length. (It should be noted that this is indeed an Er:YAG laser and nothing to do with a CO_2 laser. The name CO3 is regarded as a marketing tool by the manufacturing company.) The longer the pulse, the greater the thermal coagulation of tissue (Bob Adrian, personal communication). There is good evidence that very significant improvement of photodamaged and aging skin can be achieved with this laser. Personally, I have not seen the same degree of desiccation ("tissue contraction") while using this laser when compared to the other two modulated Er:YAG lasers.

The Contour laser is characterized by a pulsed process called optical multiplexing. Essentially, this process stacks together groups of individual Er:YAG pulses to create either short, ablative pulses of high fluence or coagulative micropulses of low fluence. The latter can produce significant degrees of thermal burn, equivalent to the CO_2 laser. These pulses can be delivered as purely ablative, or ablative and coagulative, with the ablative component being immediately followed by a coagulative component. Another departure seen in this system is the ability to dial in clinical relevant units. On the basis that 1 J/cm^2 will ablate 2–4 microns of tissue, one can closely approximate the number of microns that will be vaporized with a certain fluence. Thus, the panel displays both the ablation and coagulation depths in numbers of microns. Another important safety aspect is the immediate conversion of displayed fluence when the degree of overlap is altered. An increase from 10% to 30% overlap increases the delivered fluence by approximately 65%. Such information is tremendously important to the treating physician.

In recent months, there has been some interesting work performed with this system using degrees of overlap that might previously have been considered excessive (personal experience). Using 50% overlap, with 84 microns of ablation (21 J/cm^2) and 50–100 microns of coagulation, the visual experience is very similar to treatment with the CO_2 laser. Specifically, these parameters induce very significant tissue contraction. This contraction was associated with good to excellent control of bleeding. Taking this approach further, impressive control of bleeding can be achieved even after four passes of 50% overlap at 84 microns ablation (21 J/cm^2) and zero (0-μm) microsecond-domain, low-fluence coagulative pulse. This result is probably related to the uniform degree of vaporization and the absence of drilling artifact, which may be responsible in part for the significant bleeding obtained with the conventional Er:YAG laser at 20–30% overlap. The benefit of using very significant degrees of overlap could be applied to the conventional Er:YAG lasers.

Many of the lower-powered Er:YAG lasers are slow and may take multiple passes to remove the epidermis [5,6]. One advantage of the more powerful Er:YAG lasers such as the Contour is that very high energies can be delivered rapidly and in a uniform manner when using the scanner. There seems little advantage to stripping off the epidermis cell by cell. It would seem more appropriate to remove the entire epidermis with one pass. It is often said that Er:YAG lasers can only be used for superficial resurfacing. Clearly, this concept is erroneous. Repetitive pulses on the same location can achieve very significant degrees of ablation. One pulse followed quickly by another will vaporize tissue before the area starts to bleed. The vaporization efficiency may be reduced after multiple pulses, but this is modest in relation to the ablation plateau induced by the CO_2 laser and is also associated with increasing thermal damage [7]. Those who are used to seeing the usual "specific color changes of depth" with the CO_2 laser will be surprised by the absence of "chamois" discoloration. Indeed, this is a prime example of how the Er:YAG laser may be technically more difficult to use than the CO_2. One certainly uses a technique different from that used with the CO_2 laser.

One also needs a regional anatomic concept when using the Er:YAG laser. Fine wrinkles on the eyelids cannot be created in the same fashion as acne scarring on the cheeks. A detailed technical outline is published elsewhere [8].

The incidence of permanent hypopigmentation after CO_2 laser skin resurfacing is being reported to be 15–20% or higher (recent observations at the 1999 Controversies and Conversations Symposium, Napa, CA). In our series of over 50 patients undergoing Er:YAG laser resurfacing at UCSF, we have noted only two cases of perma-

nent hypopigmentation. (This rate does not include cases of pseudo-hypopigmentation, which, as expected, is almost ubiquitous). We believe that this potentially disfiguring complication is related to a combination of factors, including depth of vaporization and residual thermal damage.

SUMMARY

If a laser surgeon is happy with the results obtained with a high-energy, short-pulse CO_2 laser, then there would seem little reason to consider changing to an Er:YAG laser. However, the modulated Er:YAG lasers have definite advantages over the conventional Er:YAG lasers and are quite versatile. They exhibit better control of hemostasis and can ablate tissue to a greater depth than the conventional Er:YAG lasers. The Er:YAG lasers might induce less permanent hypopigmentation than the CO_2 lasers. This in itself is an important factor, given the high incidence of hypopigmentation after CO_2 laser resurfacing.

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